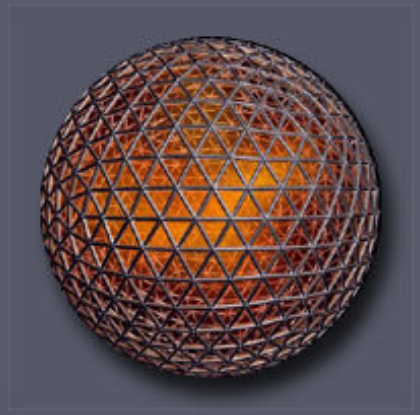

Future Energy Development Strategy:

The Global Energy Network

Emergence of the Next "World Wide Web"

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International Development:
Statement of Need

- UN World Food Program Report (Feb. 17, 2007)
- 850 million people are "hungry or malnourished"
- Half of this number are children
- 18,000 children die of starvation every single day

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Worldwide Hunger: 18,000 Children Die Every Day

Compared to Stanford University Student Enrollment

- Undergraduate Students: 6,422
- Graduate Students: 11,325
- Total Enrollment, Stanford 17,747

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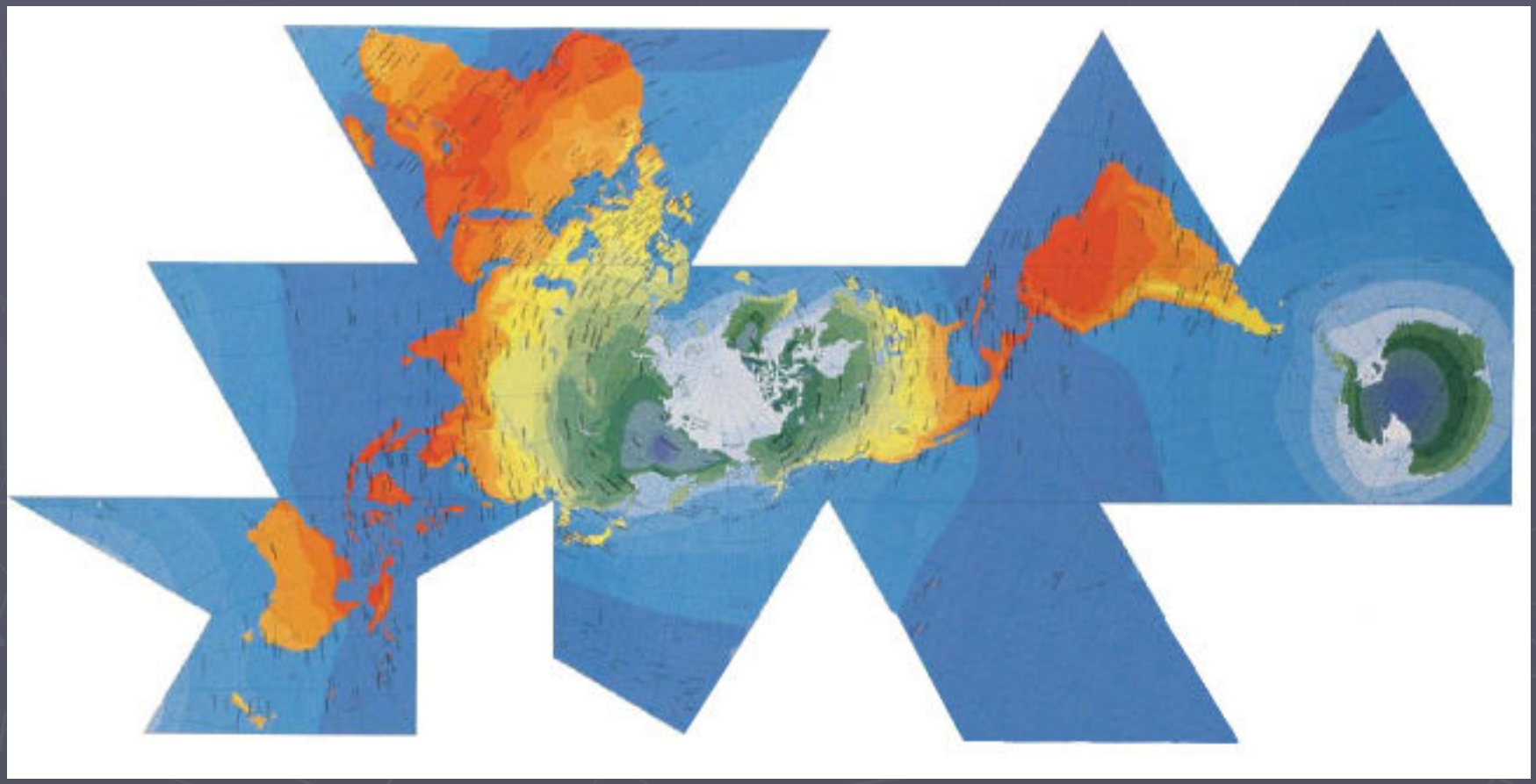
Concept of Global Energy Network

- Connect regional electricity grids into worldwide energy network



Concept of Global Energy Network

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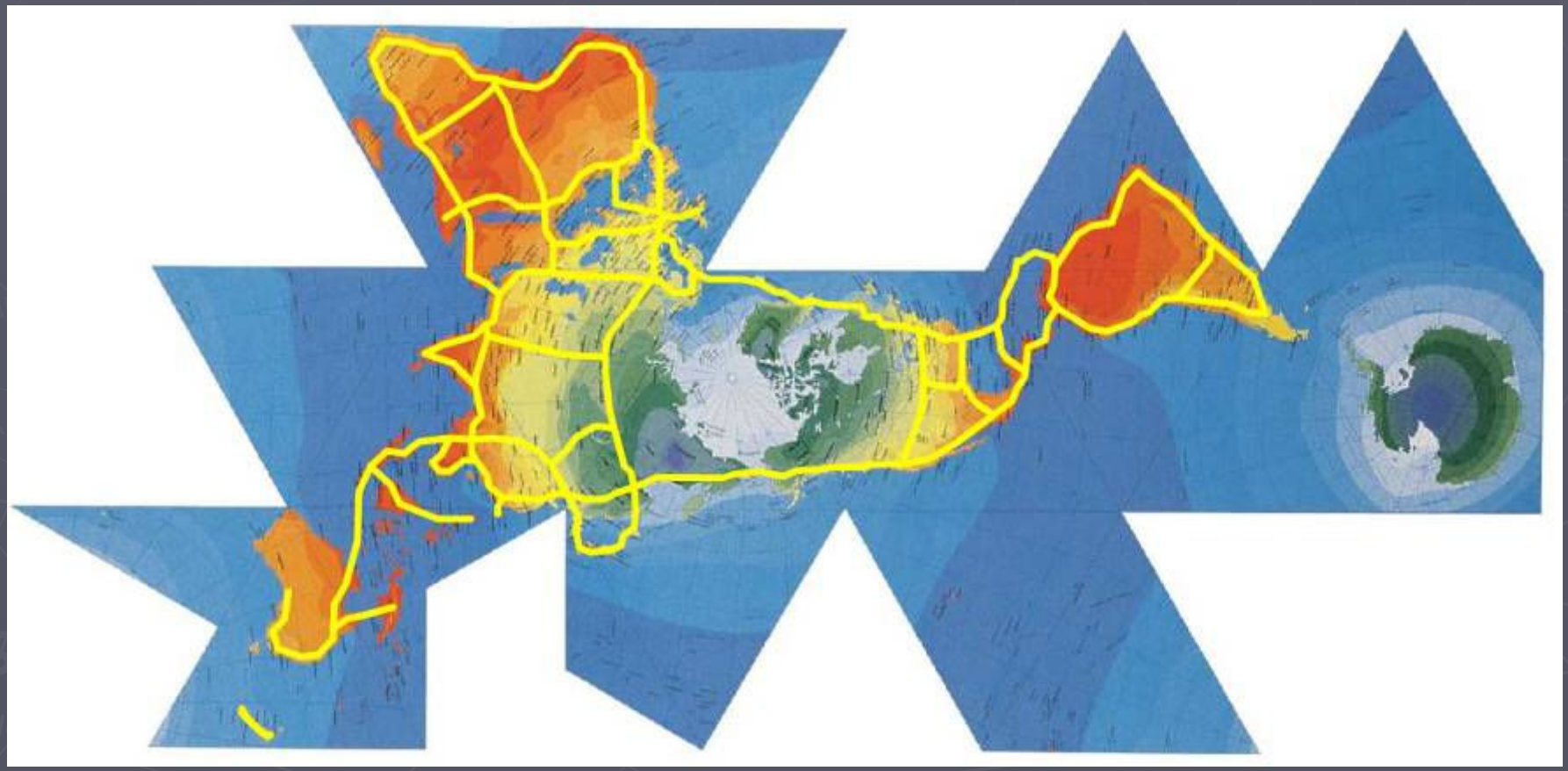
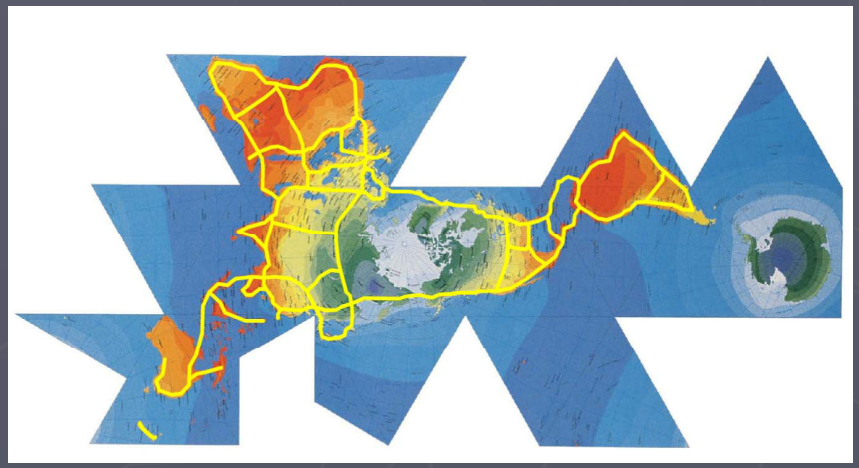


The Global Energy Network

- Connect regional electricity grids into worldwide energy network
- Connect renewable energy resources (hydro, solar, wind)
- Phase out energy generating plants causing greatest pollution
- Provide universal access to electricity
- 2,000 kWh per capita/year



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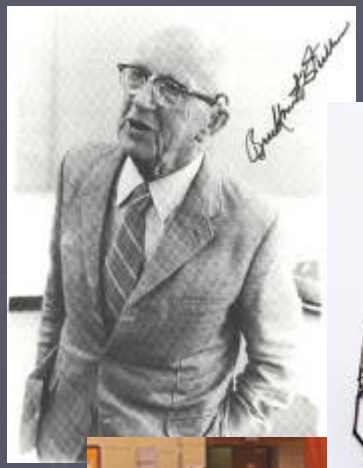
The Global Energy Network

- Proposed by Dr. R. Buckminster Fuller, inventor of Geodesic Dome

- First suggested at World Game simulation workshops in 1970's



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Dr. R. Buckminster Fuller

Special Collections, Stanford University Library

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World Game
Simulation Workshops

- Conducted at colleges and corporations in 1970's
- Simulation exercises - opposite of "war games"
- War games prepare for war; world games prepare for peace
- World Game Objective:
  - "How can we make the world work…
    for 100% of humanity…
    in the shortest possible time…
    through spontaneous cooperation…
    without ecological damage or…
    disadvantage to anyone?"
- Highest priority strategy: Global Energy Grid

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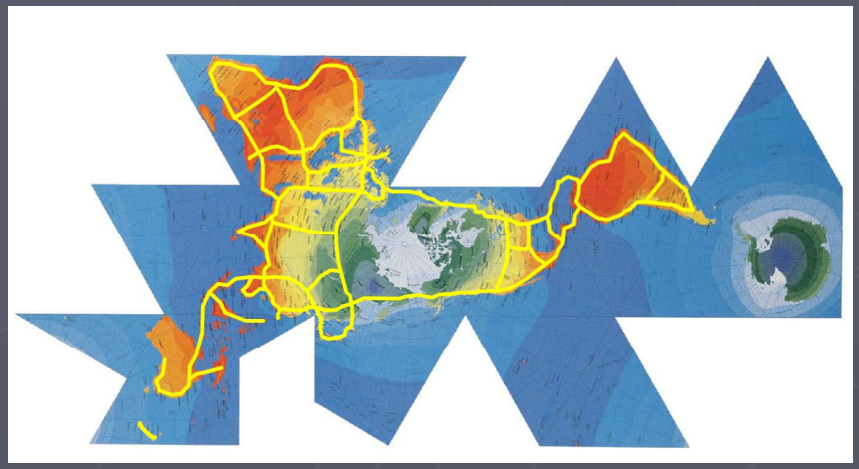
The Global Energy Network:
Potential Benefits

- Turn back the clock on global warming
- Universal increase in living standards
- Reduction in hunger and poverty
- Stabilize population growth
- Increase in trade, cooperation and peace between nations



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Unique Properties of Electricity

- Basis of civilization – access to electricity sets standard of living
- Fastest way to balance earth's "energy accounts" – travels at the speed of light
- Can't be easily stored
- Used on a time-sensitive basis (peak vs. off-peak)

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Electricity: Basis of Civilization

- Developed world: 2,000+ kWh per capita

- Developing world: 1,000 – 2,000 kWh per capita

- Poverty: Less than 1,000 kWh per capita

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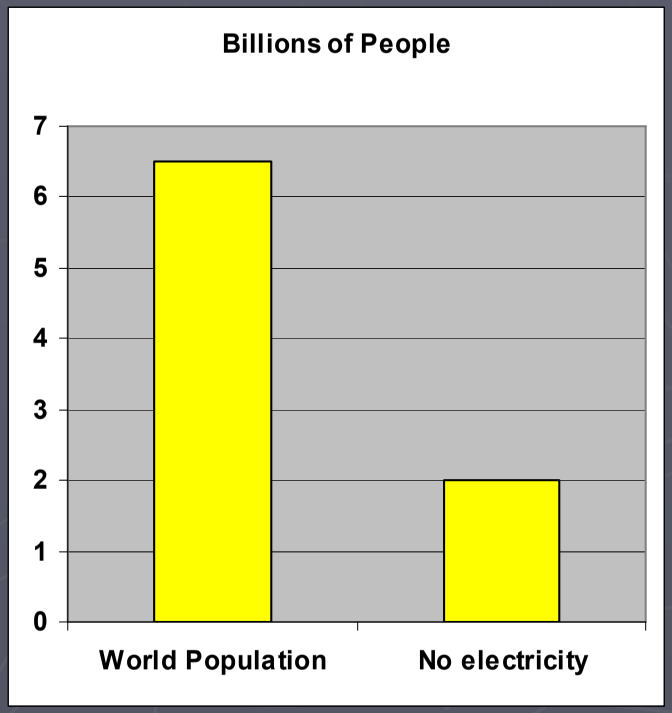
Electricity: Basis of Civilization

- Current world population

6.5 Billion people

- People with no access to electricity:

2 Billion people



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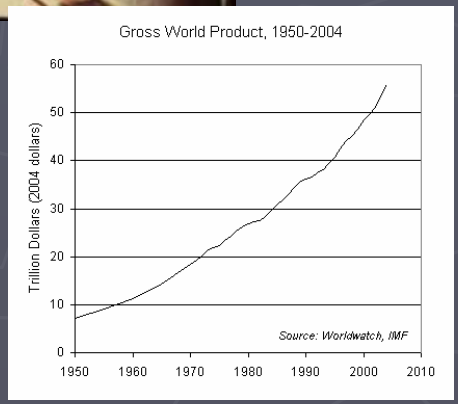
Electricity: Basis of Civilization

- Clean drinking water and adequate water treatment systems
- Refrigeration: stable food supply and medicines
- Reduction of disease and infant mortality
- Improved standard of living: stable population growth
- Correlates with high literacy rate
- Stable economy with steady job growth



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Electricity: Supply vs. Demand

Fastest Way to Balance Earth Energy Accounts

- Earth's Daily Energy Input:

  174,000 Terawatts

- Earth's Daily Energy Needs:

  13.4 Terawatts

- Every day, Earth receives

  12,000 times

  as much energy as civilization uses

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Electricity: Supply vs. Demand

Fastest Way to Balance Earth Energy Accounts

- Energy Not Always…
  - the right kind of energy
  - at the right place
  - at the right time…
- Not a supply problem, but a distribution problem
- Electricity travels at speed of light
- Only commodity that can be traded, delivered and used immediately

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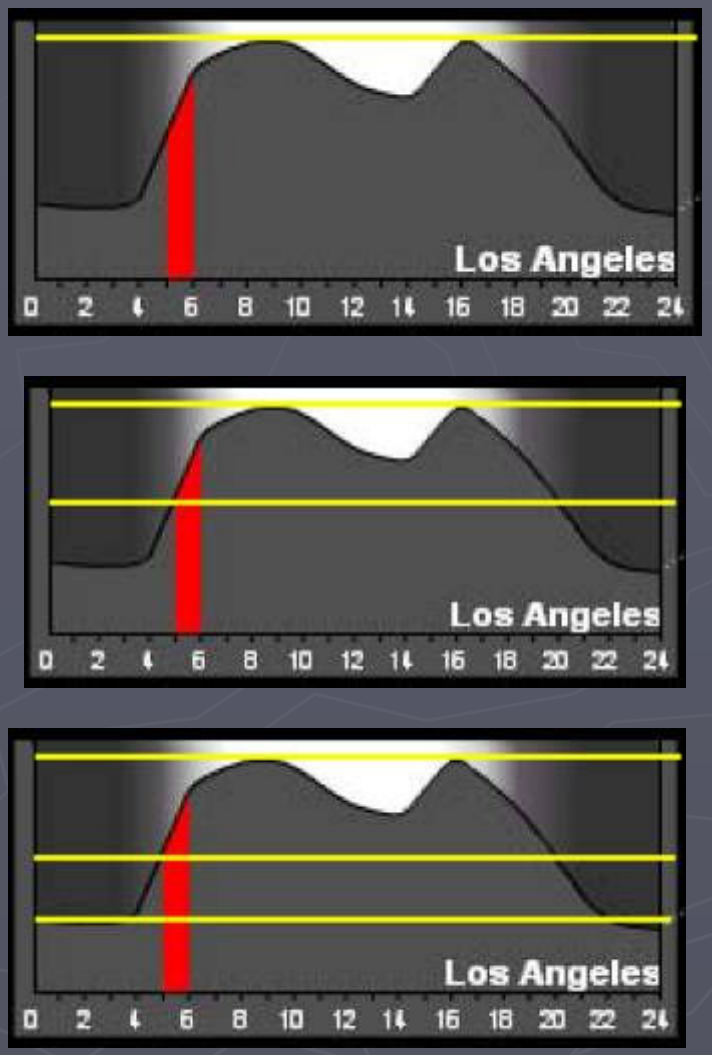
Electricity: Time-Sensitive Demand

- Electricity needs change throughout the day
- Peak needs only occur briefly during day
- Avg needs usually ½ what peak needs are
- Baseload needs usually ½ again as small
- Large amounts of energy wasted as generating facilities are started and stopped during the day



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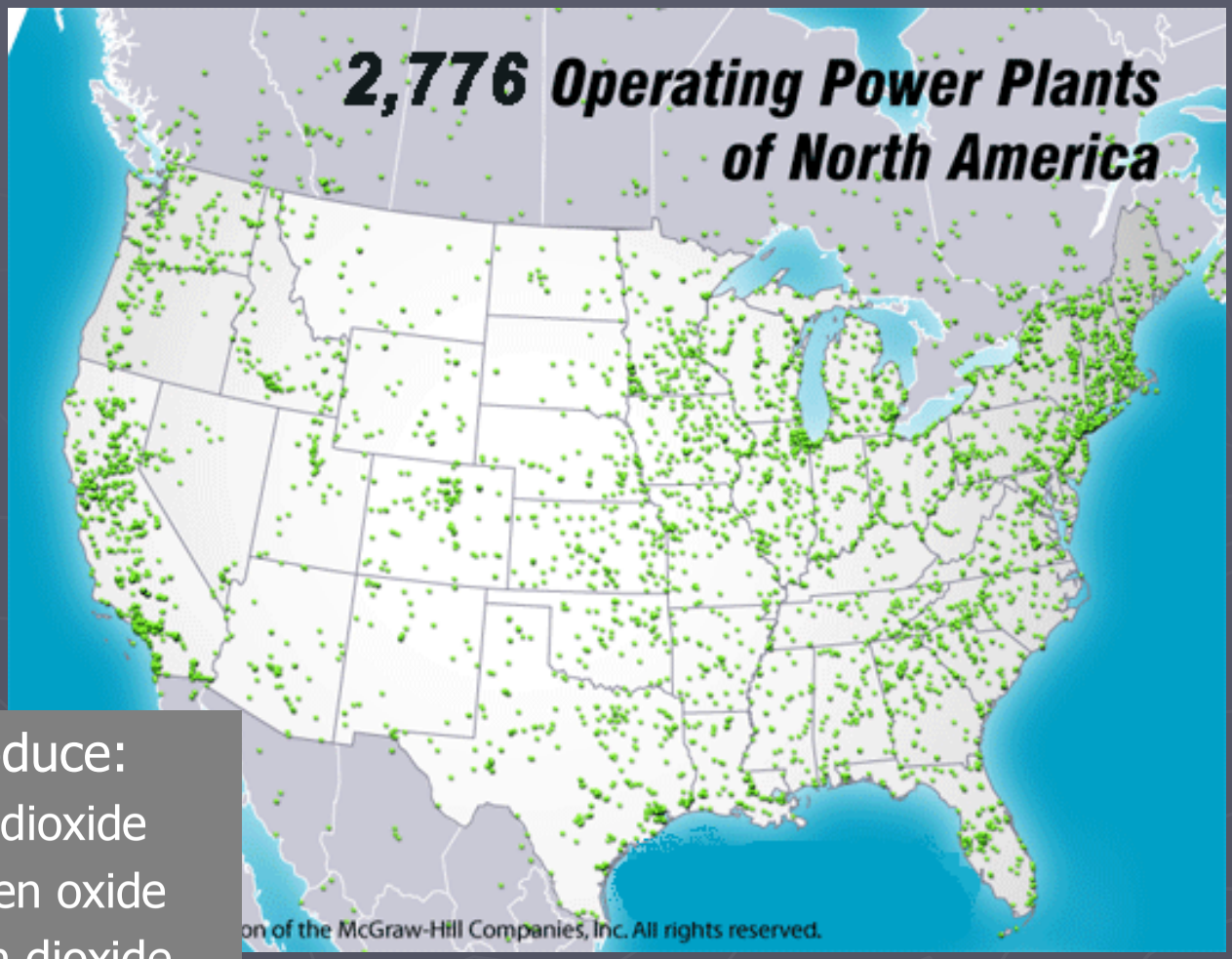
Option 1: Power Plants Respond to Peak Demand



- Power plants produce:
  - 59% of sulfur dioxide
  - 18% of nitrogen oxide
  - 40% of carbon dioxide
- Over half use coal

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Option 2: Electricity Energy Transfers

- Bulk power transfer more efficient than transient generation
- Over 35% of all energy sold now bulk power transfer

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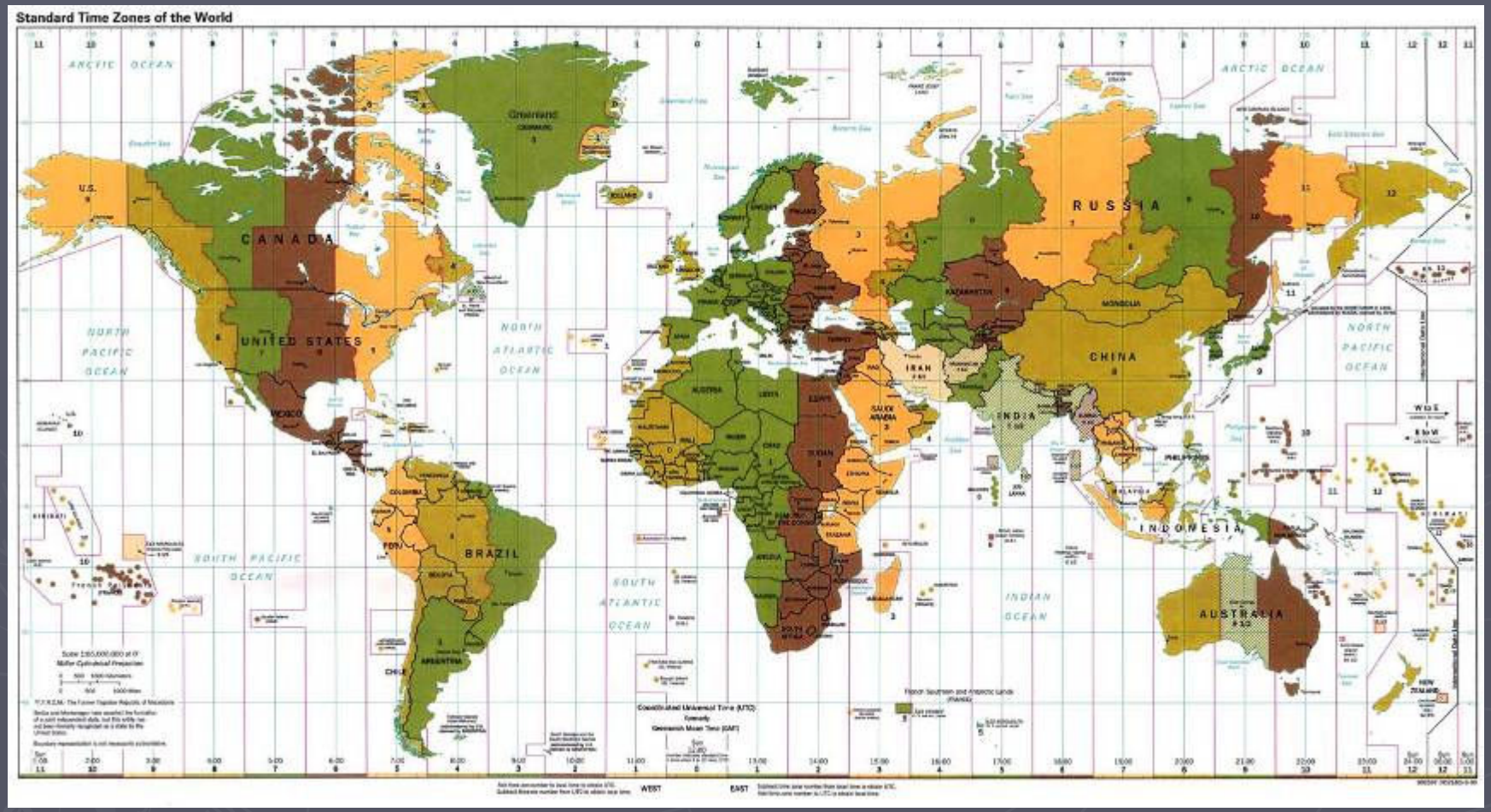
24 Time Zones Worldwide



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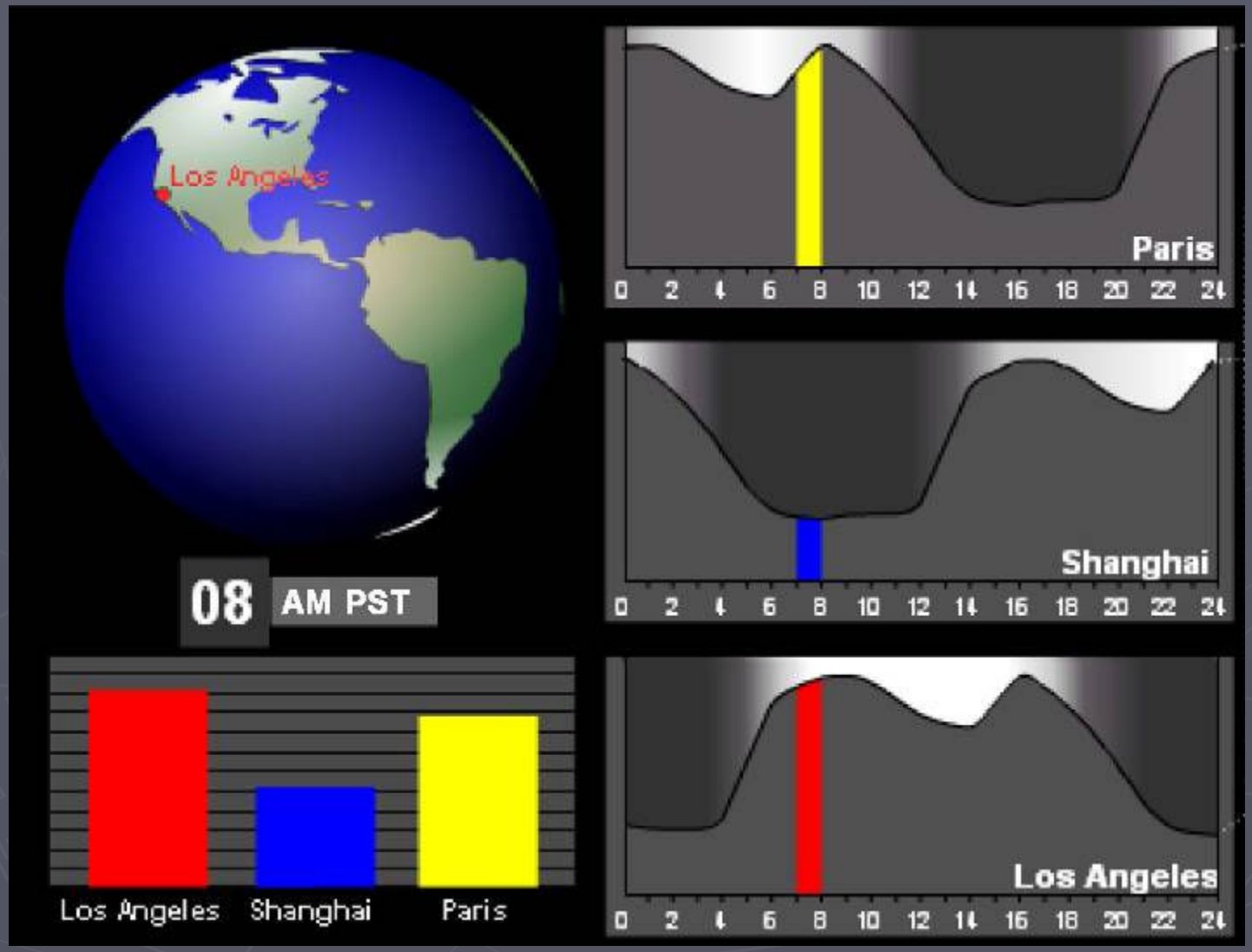
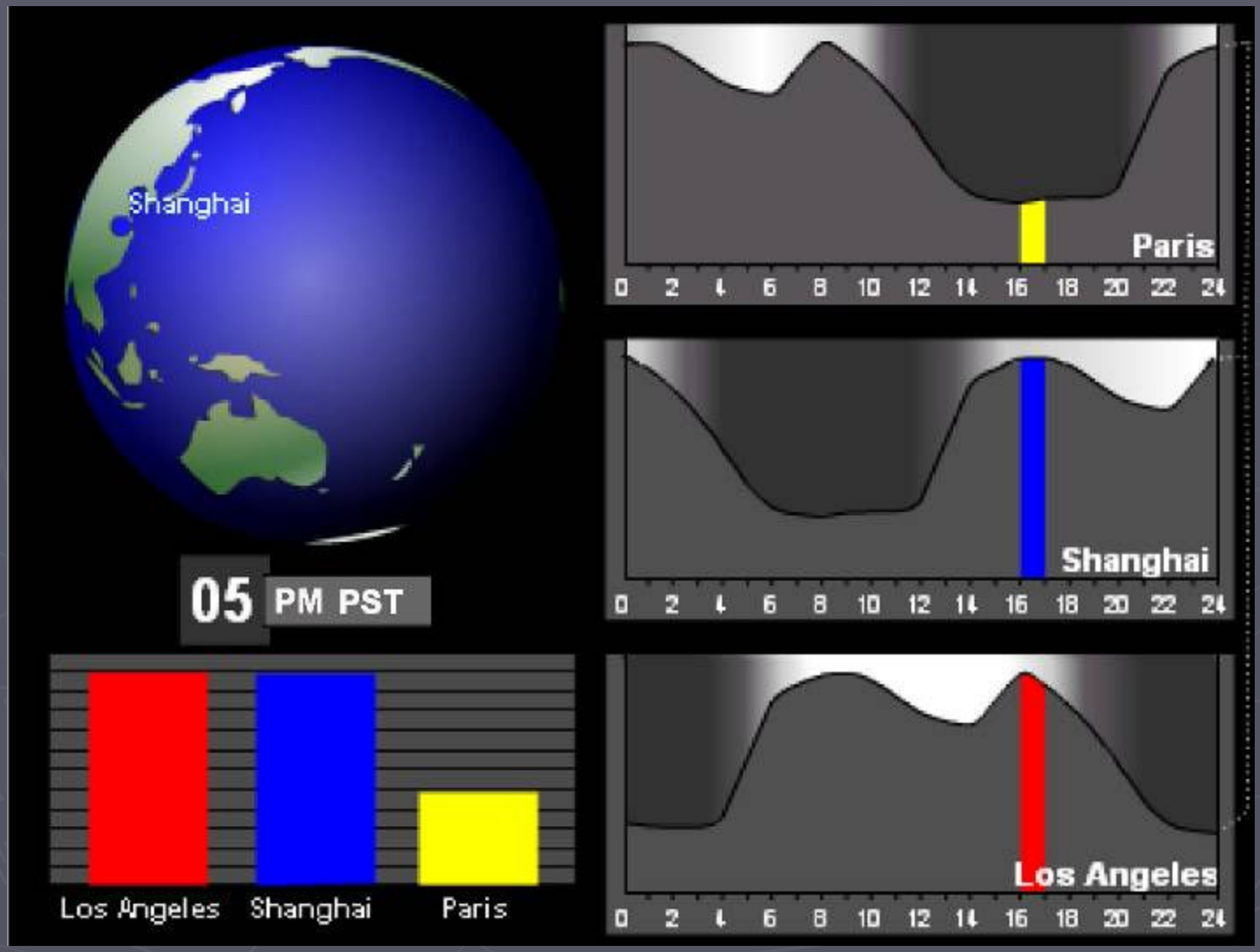
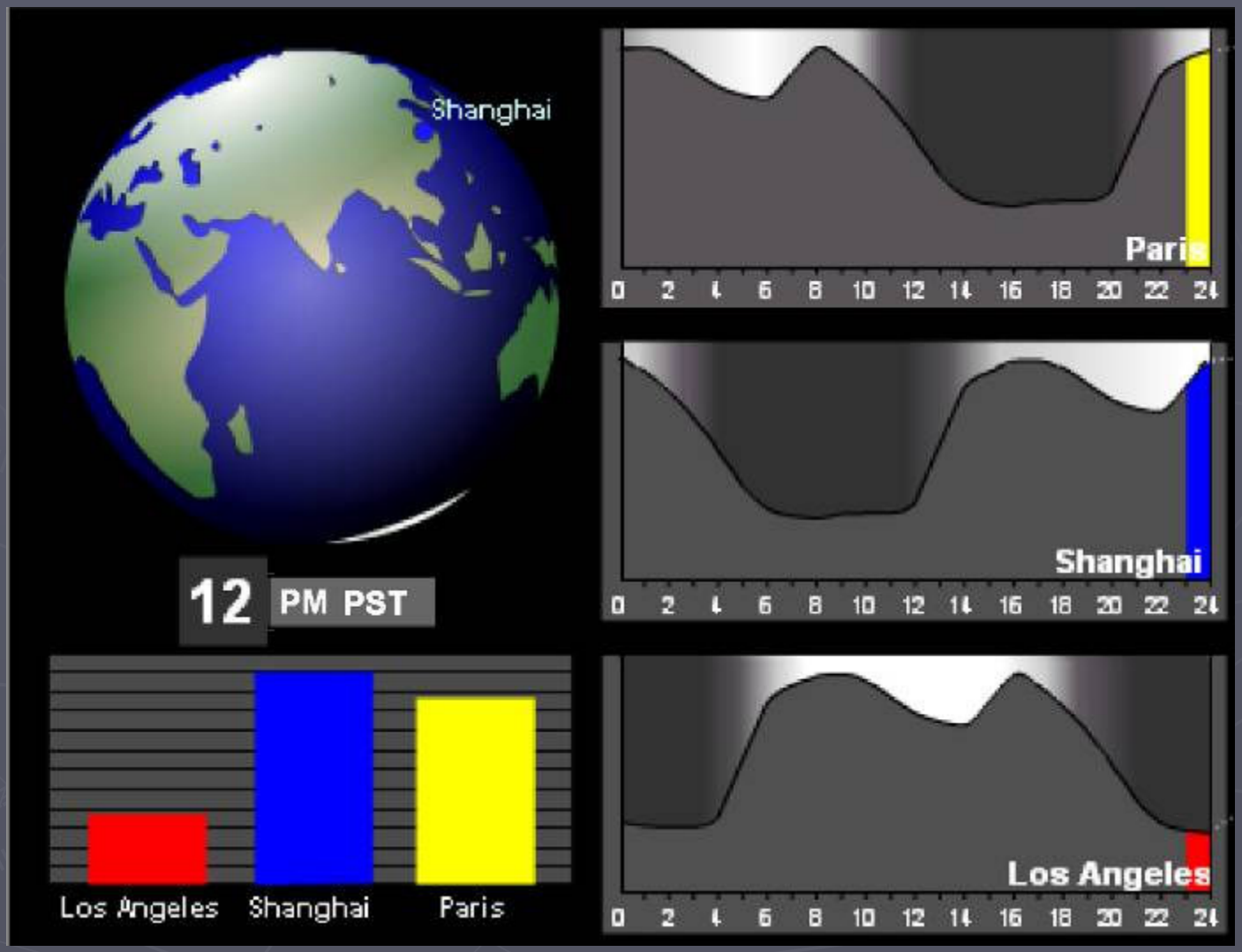
Electricity Meets Changing Global Needs



Electricity Meets Changing Global Needs

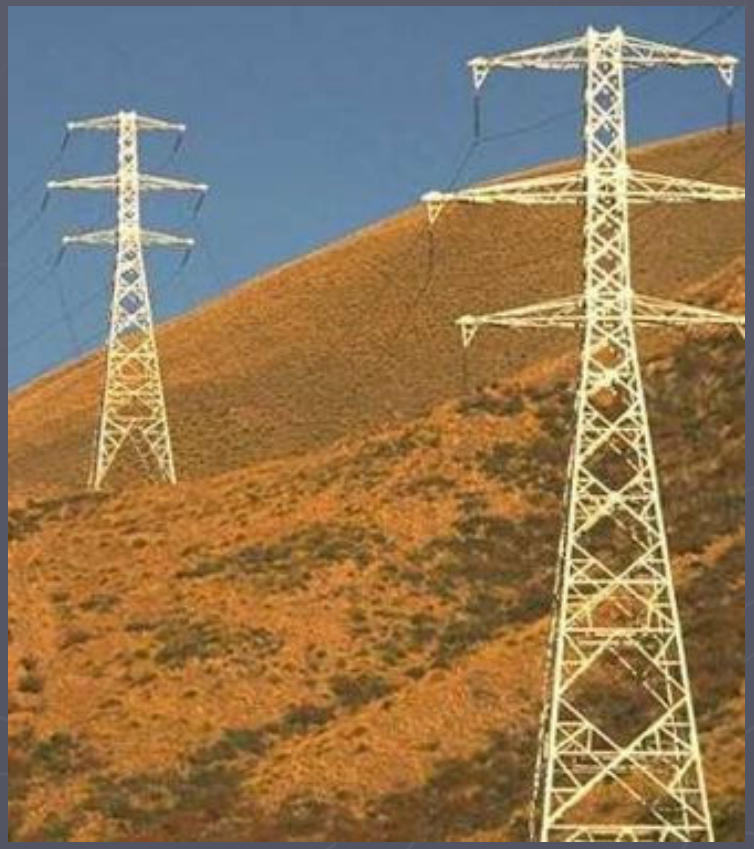


Electricity Meets Changing Global Needs

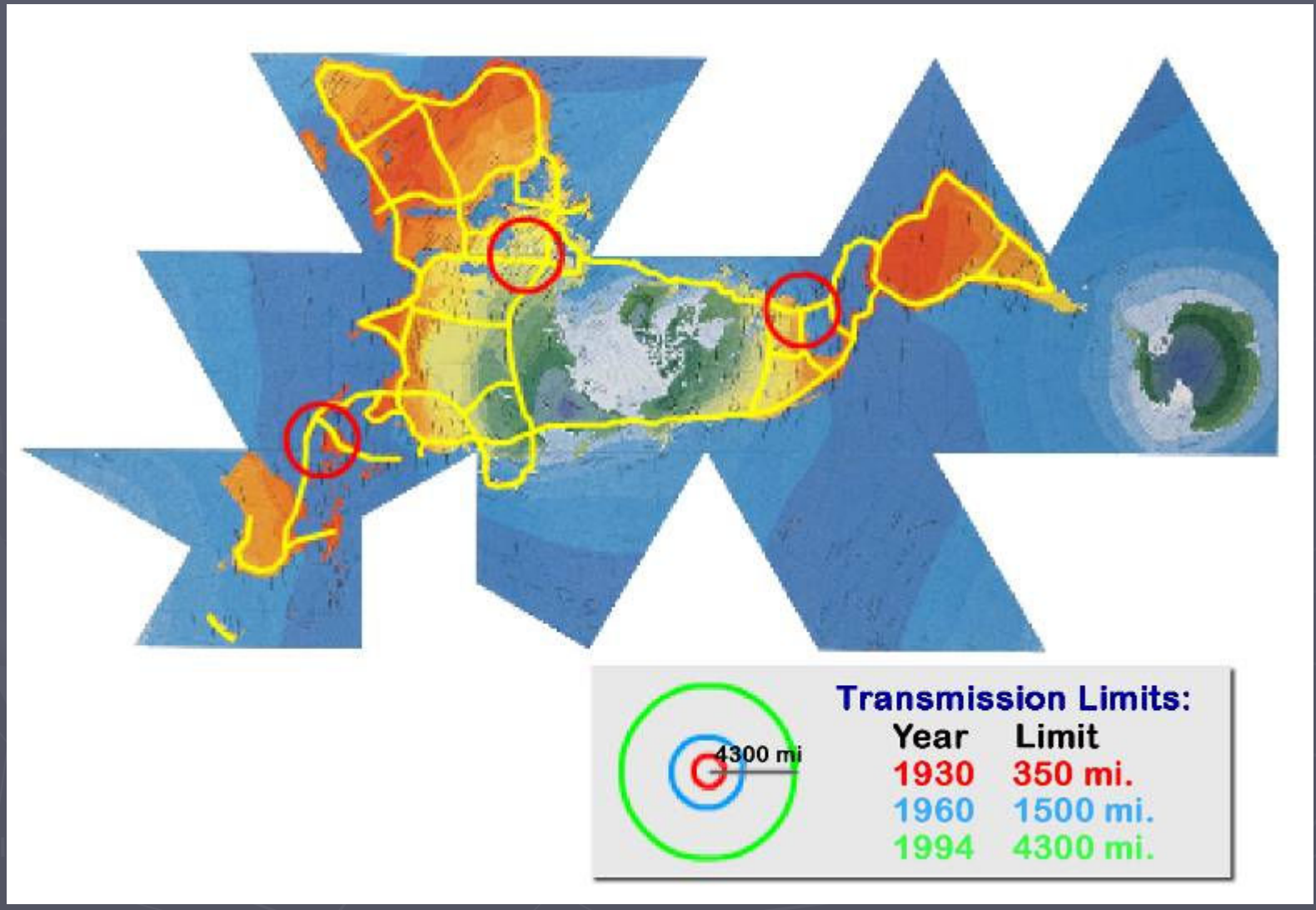


Energy Transmission Limits?

- Up until 1930's, transmission limit was 350 miles

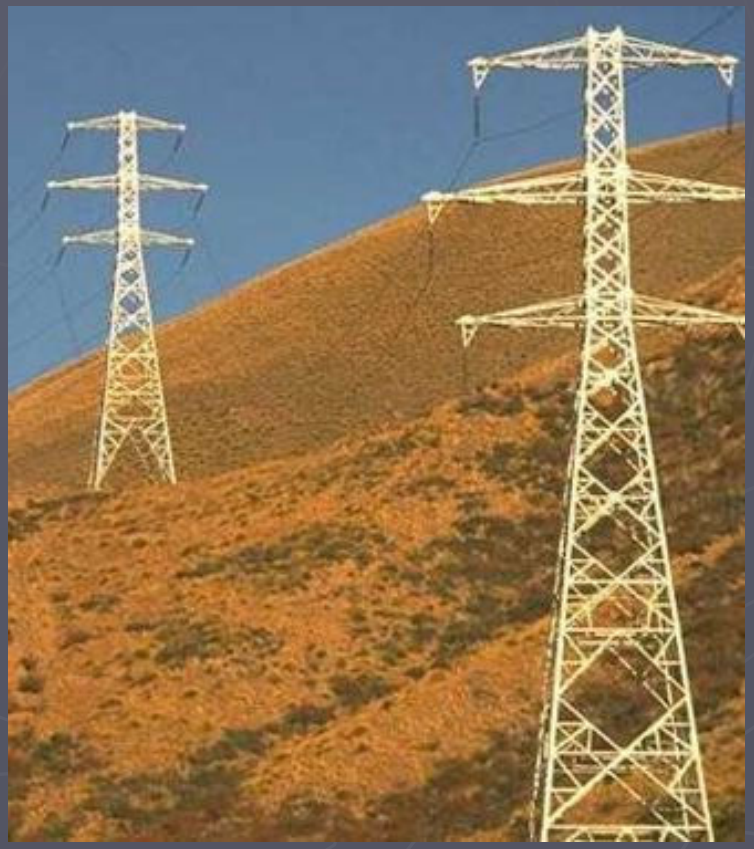


Electricity Transmission Limits

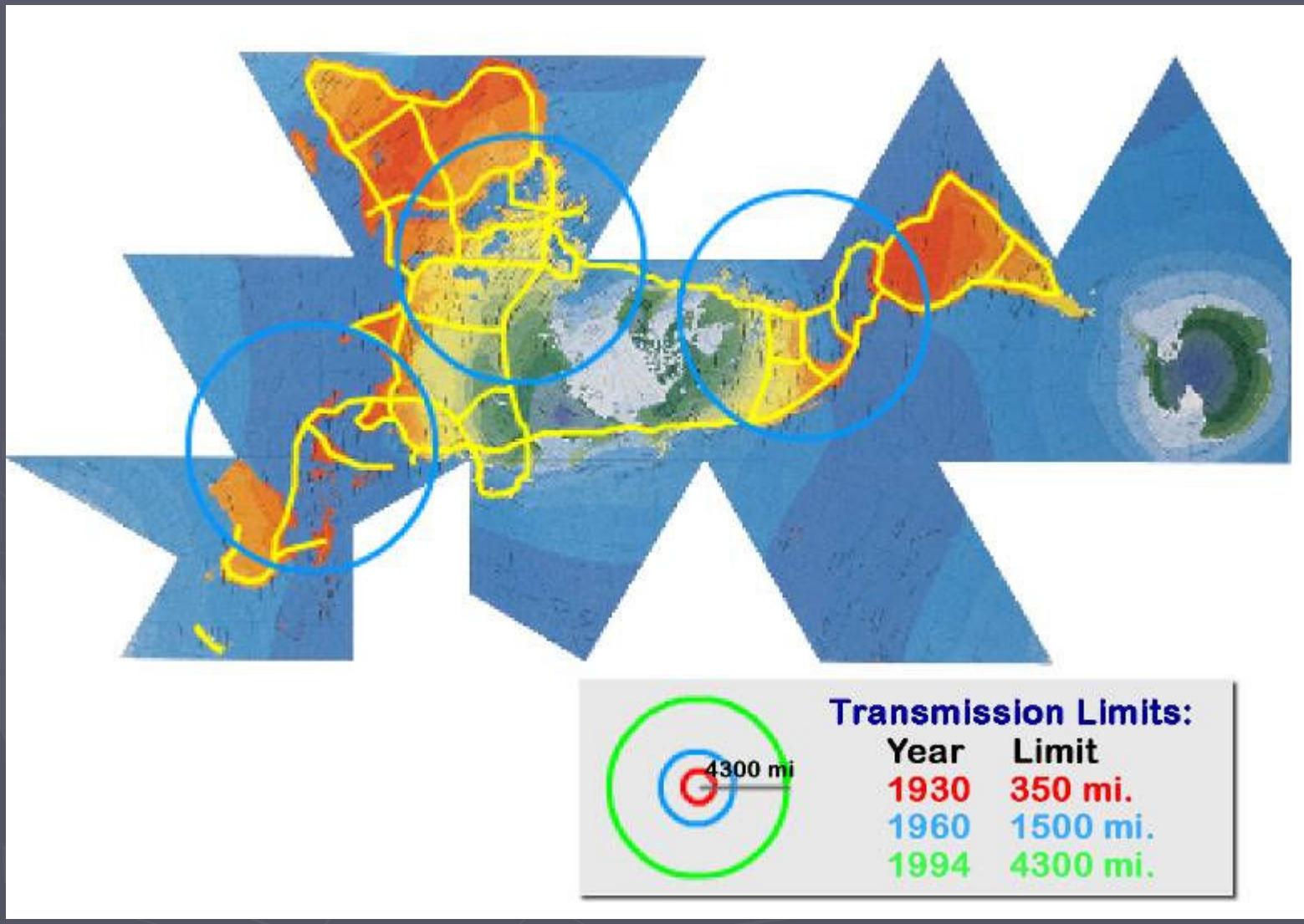


Energy Transmission Limits?

- Up until 1930's, transmission limit was 350 miles
- New technology in 1960's increased this limit to 1,500 miles

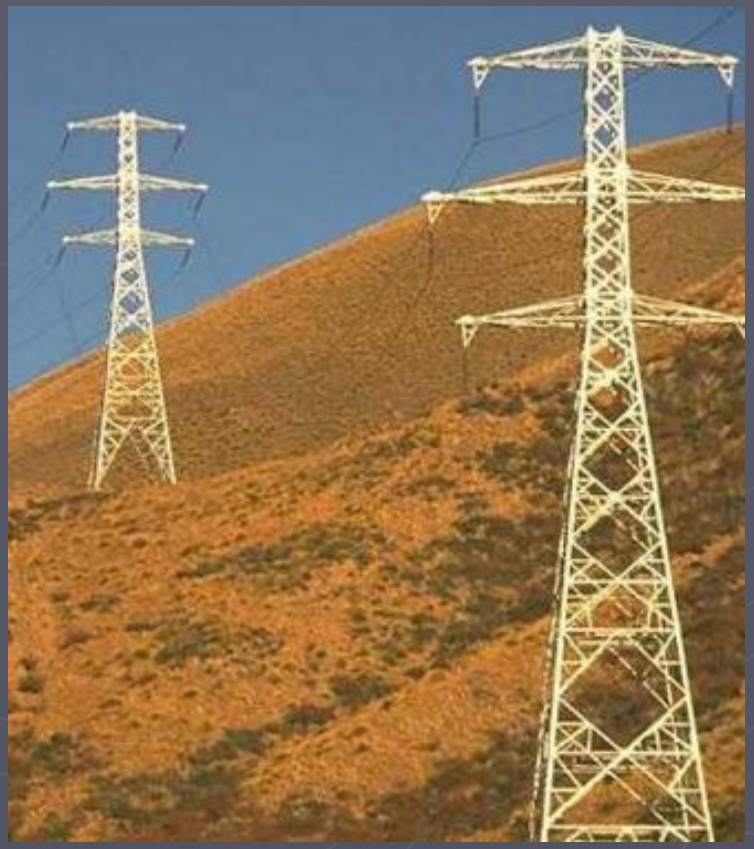


Electricity Transmission Limits



Energy Transmission Limits?

- Up until 1930's, transmission limit was 350 miles
- New technology in 1960's increased this limit to 1,500 miles
- UHV and HVDC technology now allow bulk power transfers of more than 4,300 miles



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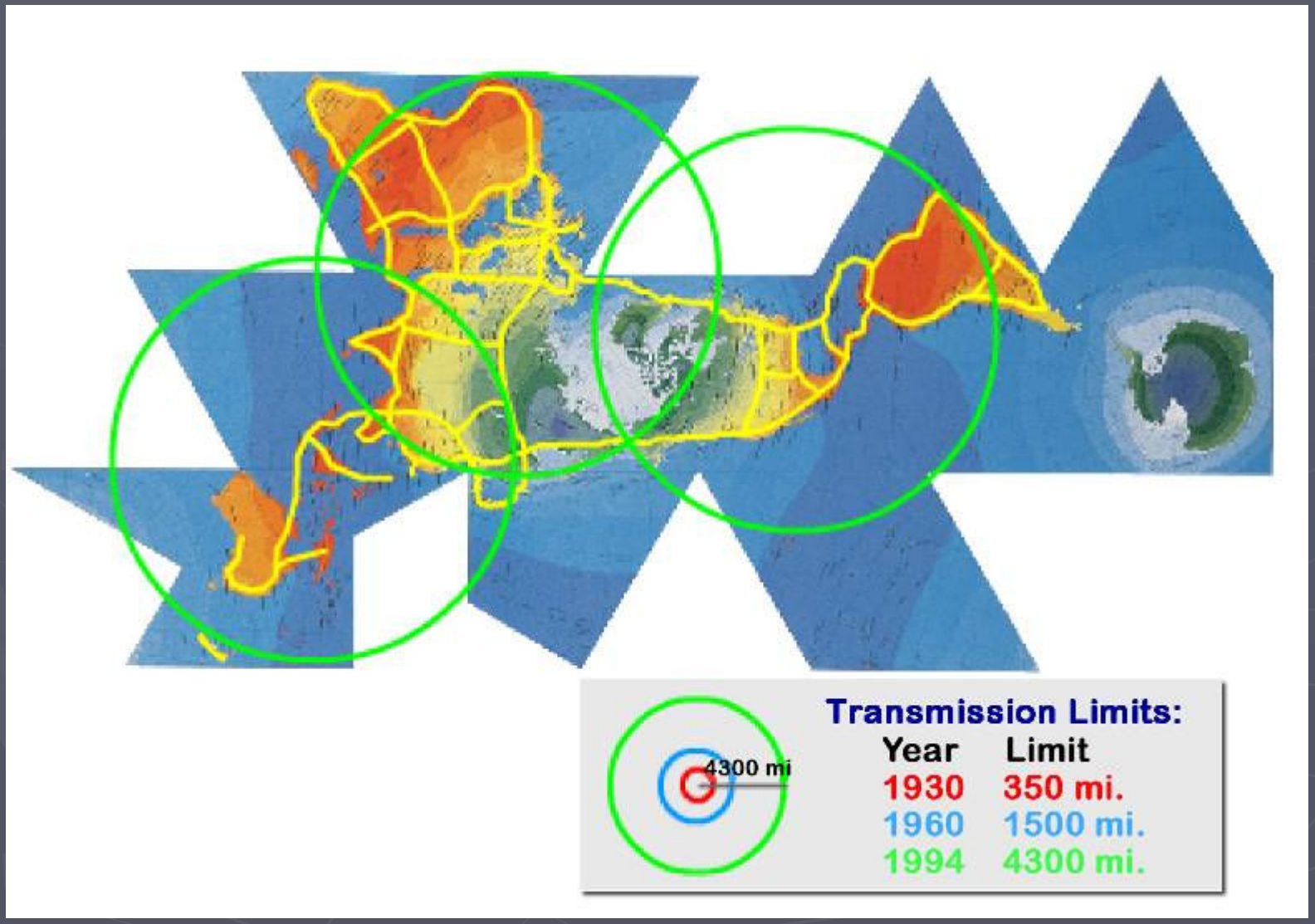
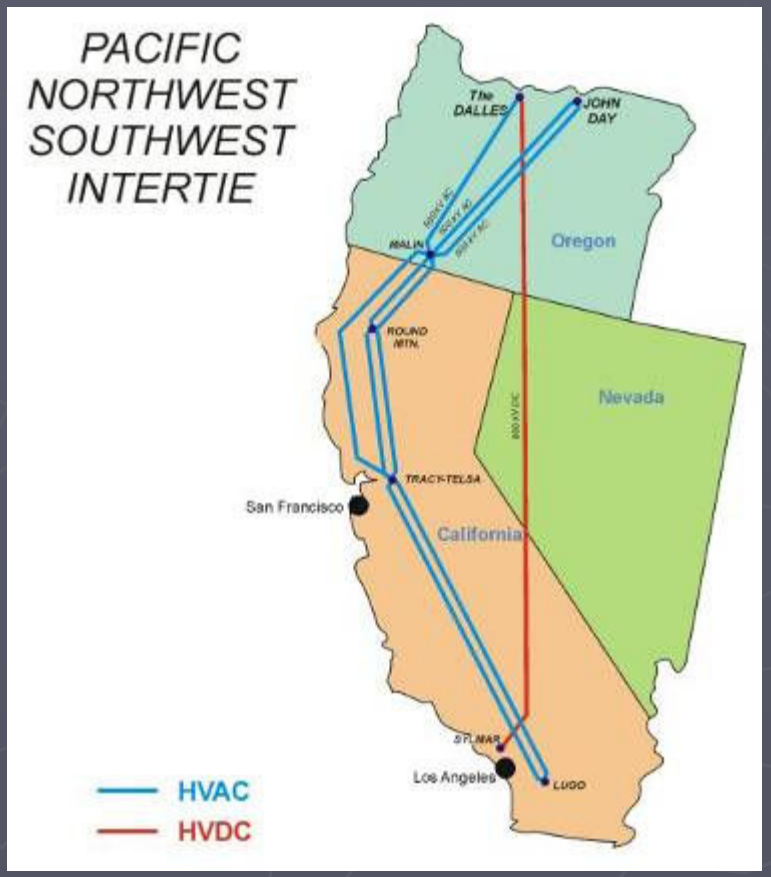


Pacific-Southwest Intertie

- High Voltage (500kV) DC Line
- Enough power to serve 2-3 million LA households
- Completed in 1972, upgraded in 1984 and 2004
- Connects Bonneville hydro power in NW to Southern California
- Line extends about 900 miles



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Electric Utility Industry Barriers

- Highly regulated for past 100+ years
- Fragmented, regional utility service areas
- Little or no incentive to invest in new transmission infrastructure
- No over-arching global strategy

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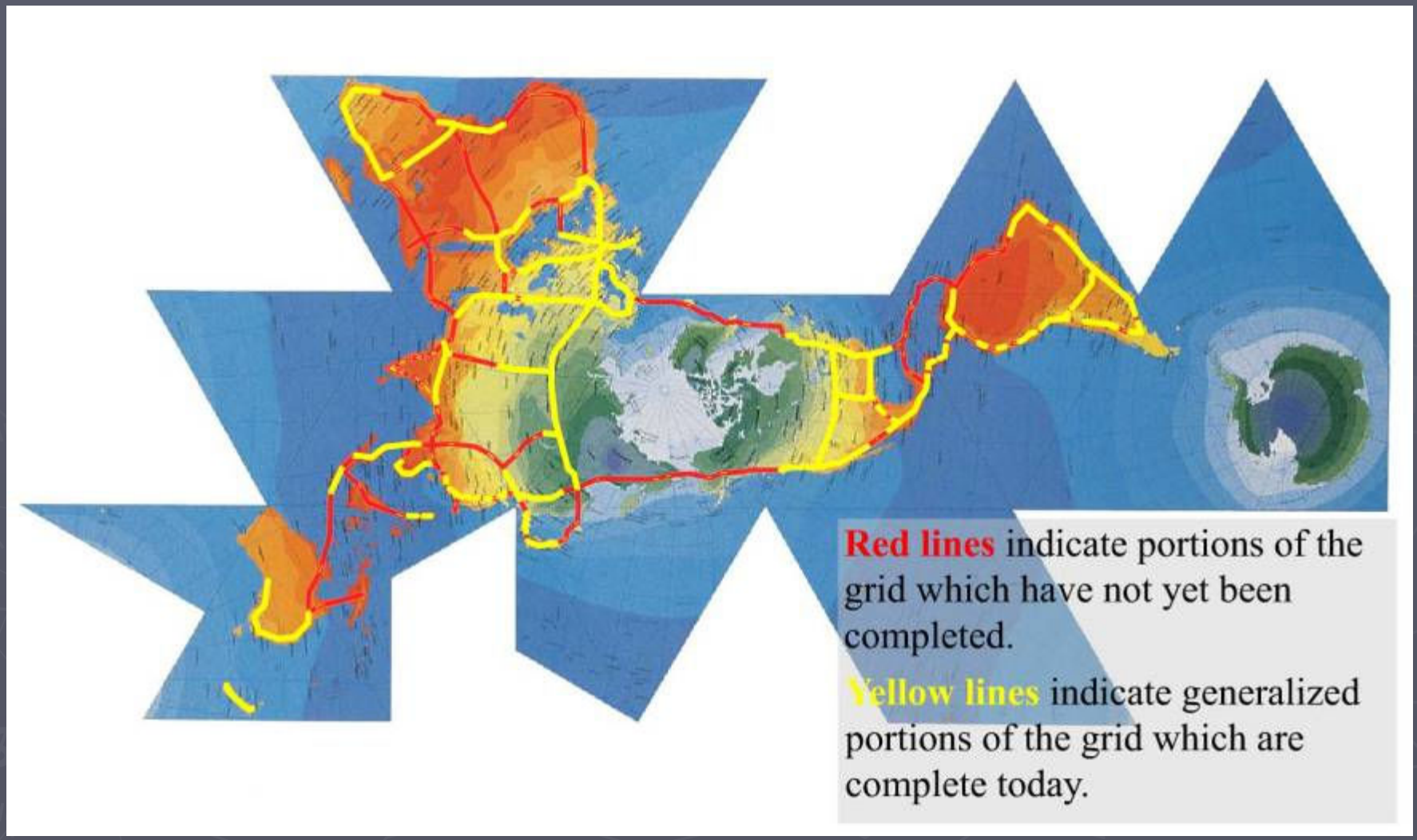
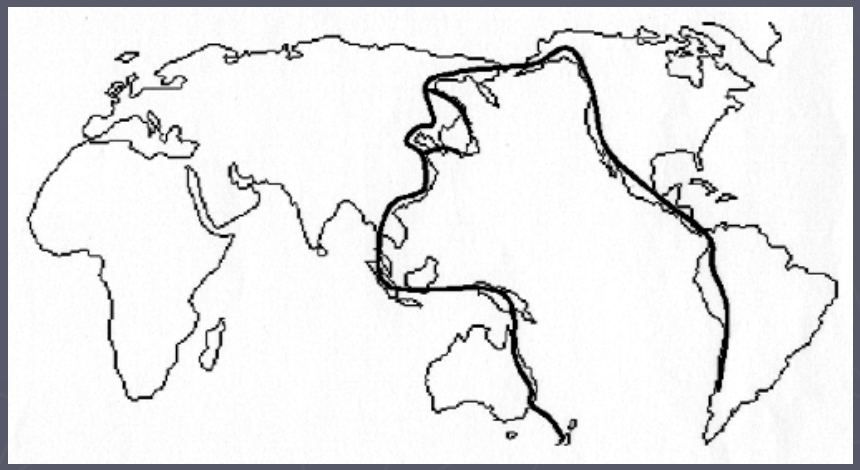
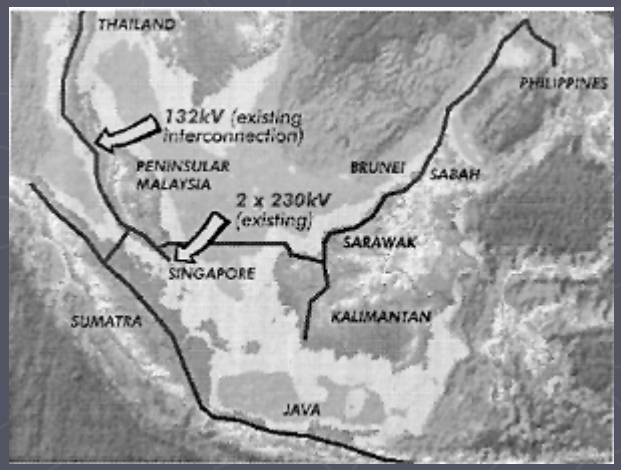
Global Energy Grid: Largely Built



Asia Pacific Rim Electricity Cooperation

- Proposed by Hitachi Research Institute in 1998
- Interconnect Pacific Rim nations with UHV and HVDC lines
- Flatten demand curve across multiple time zones
- Flatten out seasonal demands between tropical and high-latitude climates





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East-West Energy Bridge

- Symbolic connection across International Date Line

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East-West Energy Bridge

- Symbolic connection across International Date Line
- Would connect North America with Siberia across the Bering Straits

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East-West Energy Bridge

- Symbolic connection across International Date Line
- Would connect North America with Siberia across the Bering Straits
- Connection to Diomede Island midpoint is 26 miles

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East-West Energy Bridge

- Symbolic connection across International Date Line
- Would connect North America with Siberia across the Bering Straits
- Connection to Diomede Island midpoint is 26 miles
- Leg to Siberian mainland is just 22 miles

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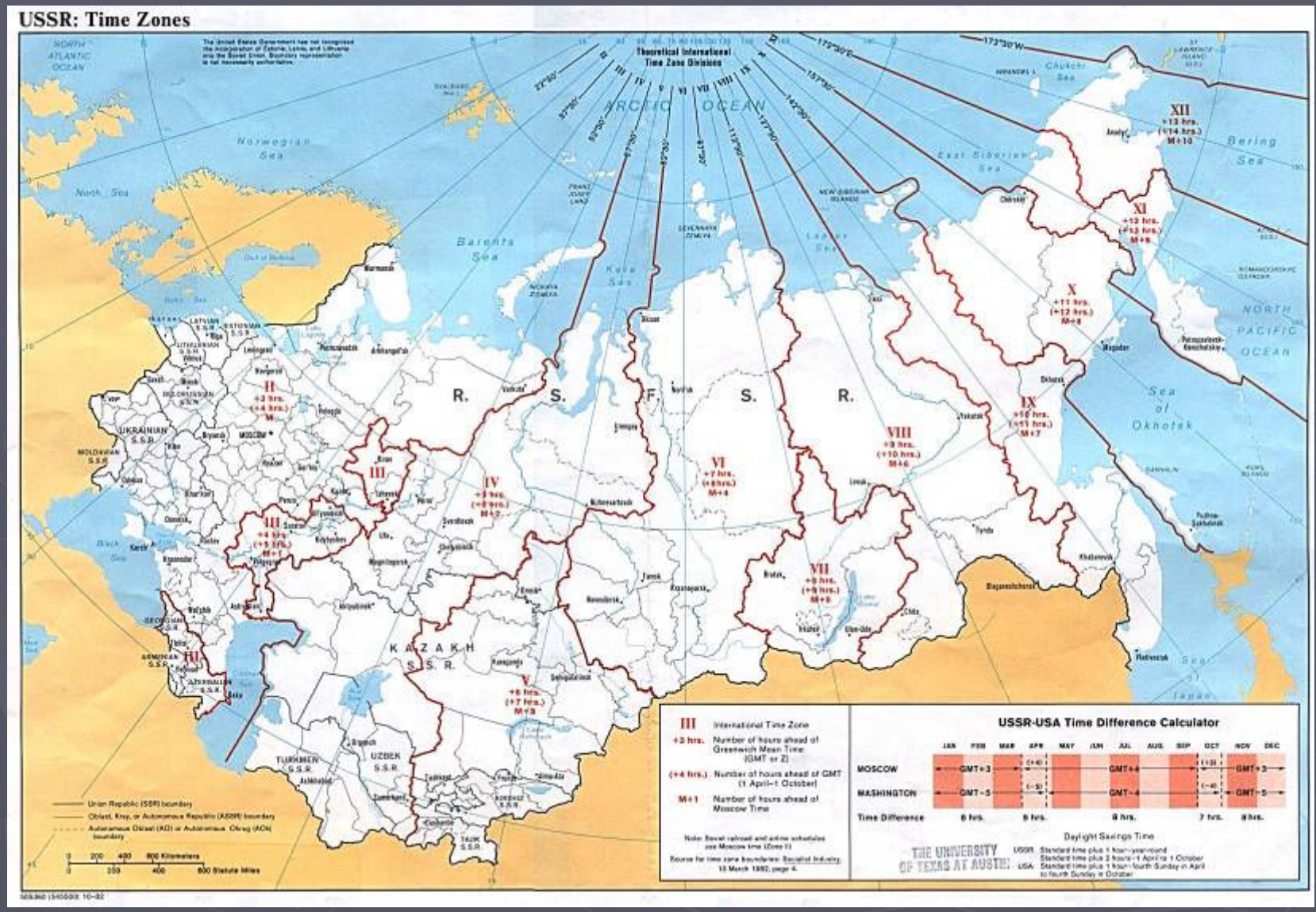
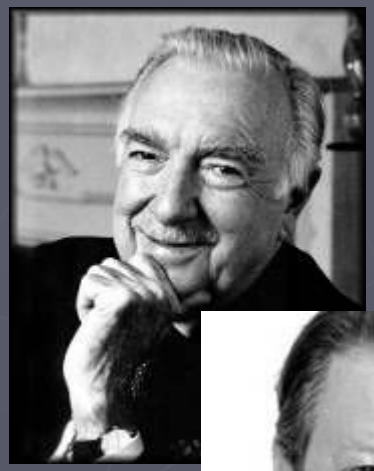
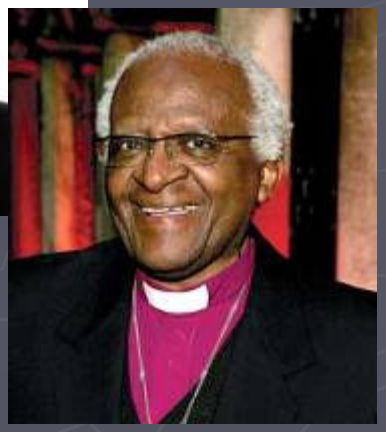
Former Soviet Union Time Zones



Global Energy Network Endorsements

- Walter Cronkite
- Al Gore
- Boutros Boutros-Ghali
- His Holiness Dalai Lama
- Rev. Desmond Tutu
- Vincente Fox
- Jonas Salk
- Senator Tim Wirth
- Senator Jim Jeffords
- Senator Alan Cranston
- Dr. Oscar Arias





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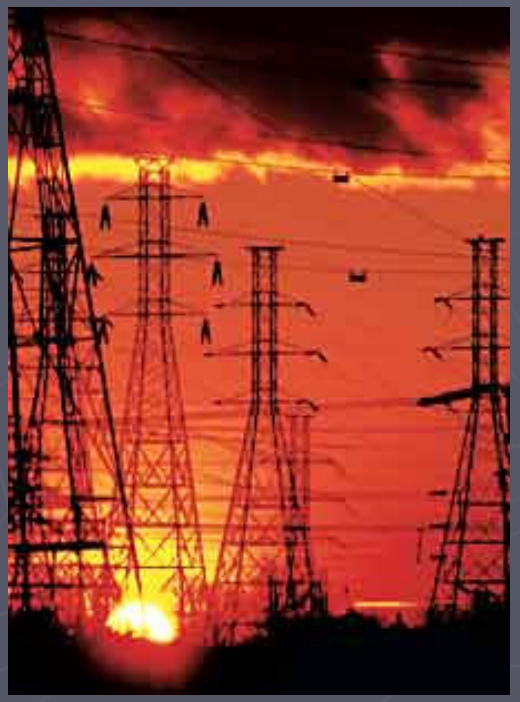
Grid-Building in 2006

- Russia and China agree to interconnect
- China also sign deals with Vietnam and Tajikistan
- South Korea offers to extend grid into North Korea
- Kenya and Ethiopia agree to supply power to each other
- Modeled after 12-nation South Africa Power Pool, 14 west Africa nations plan to link their energy grids



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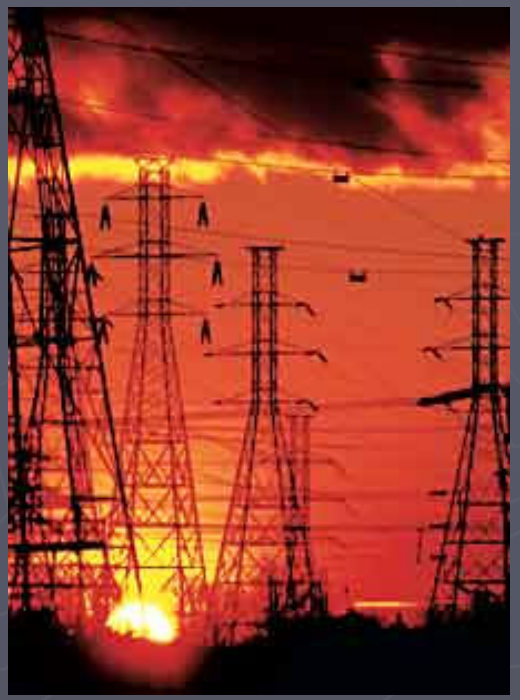
Grid-Building in 2006

- Lebanon to be linked to regional grid that includes Egypt, Jordan, Syria and Turkey
- Same project will join Libya and Iraq
- Former enemies Iran and Iraq agreed to build four cross-border power lines
- Mexico's *Mesoamerica Initiative* plans to integrate energy grids of all of the Central American nations



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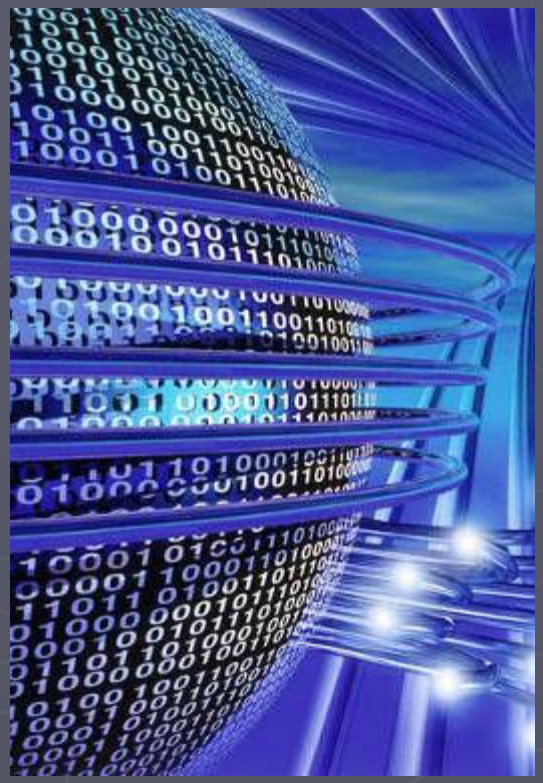
Trends Supporting Grid Growth

Technical

- UHV and HVDC technology
- Superconducting transmission lines
  - Zero resistance, zero power loss
- "Smart Grid" strategies:
  - Interactive energy management
  - Robust data transmission
  - Real time pricing and communications between producers and consumers
  - Improved reliability
  - National Grid Week: April 23-26



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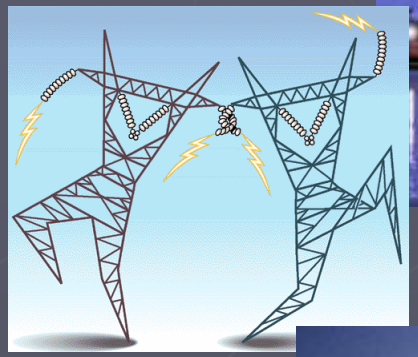
Trends Supporting Grid Growth

Economical

- High risk, cost of plant construction
- M/A activity among utility firms
- Growth of Distributed Generation
- Growth in Renewable Energy



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Micro-Generation: Home Solar

- California Solar Initiative adding thousands of small to medium-size solar energy systems
- "Net Metering" Program:
  - During day, homes spin meter backwards, selling power back to grid
  - At night, homes "buy back" power sold during the day
- Each of these solar homes are new nodes on the energy grid
- Electricity connection into house is now a 2-way pipe

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Long-Range Consequences

- Growth in renewable energy "pro-sumers"
- Aggregators seeking contracts on blocks of solar, wind and fuel cell-generated "premium power"
- New industry: Hardware and software for energy management and energy transactions
- "Peer-to-Peer" energy trading over longer distances
- Direct, individual participation in the global economy

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The Energy Challenge

"Where there is no vision, the people perish."

Proverbs 29:18

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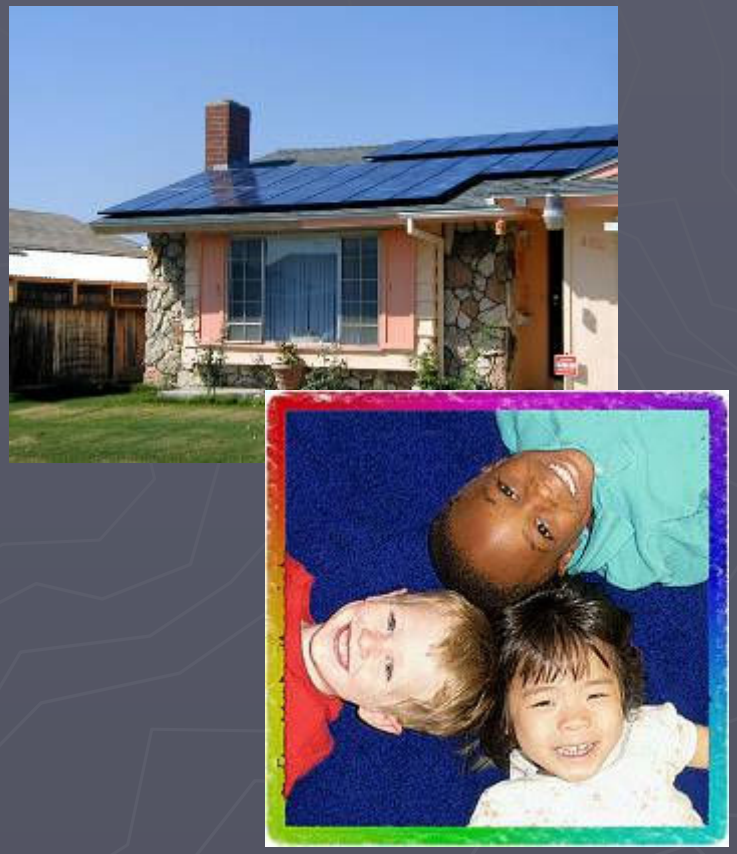
The Future Energy Vision

- A homeowner in San Jose will capture kilowatts for sale to a homeowner in Shanghai
- Instead of running all of the world's generators half the time… we will run half the world's generators all the time.
- Successful phase out of fossil fuels
- Reversal of climate change
- Universal access to electricity… and a reasonable standard of living, world-wide



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